Evaluating Self-Report Data Using Psychometric Methods

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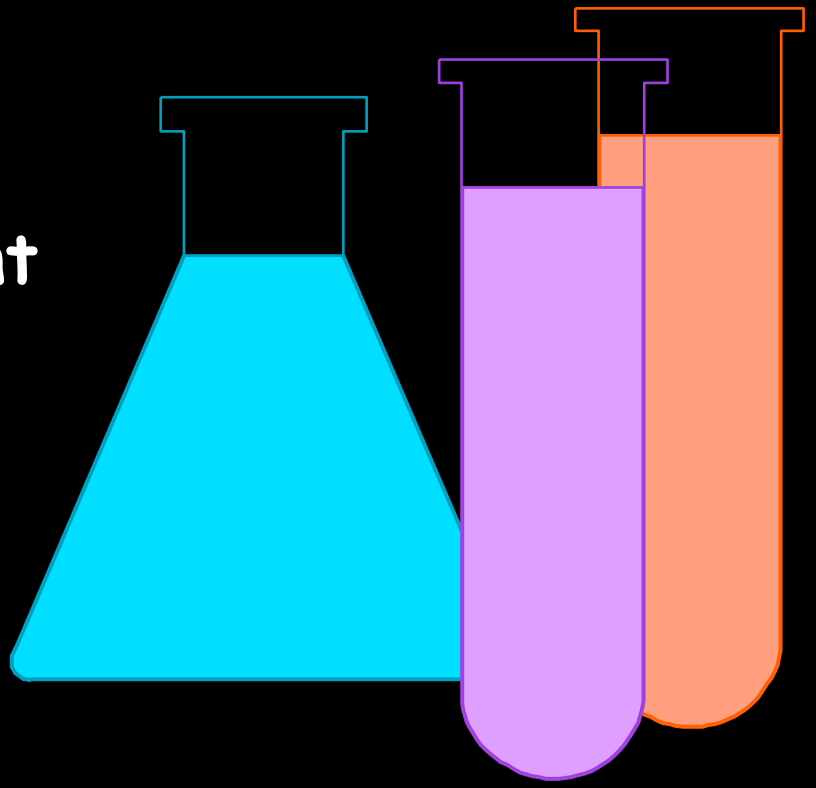
HS 249F

Four Types of Data Collection Errors

- Coverage Error
  Does each person in population have an equal chance of selection?
- Sampling Error
  Are only some members of the population sampled?
- Nonresponse Error
  Do people in the sample who respond differ from those who do not?
- Measurement Error
  Are inaccurate answers given to survey questions?

What's a Good Measure?

- Same person gets same score (reliability)
- Different people get different scores (validity)
- People get scores you expect (validity)
- It is practical to use (feasibility)



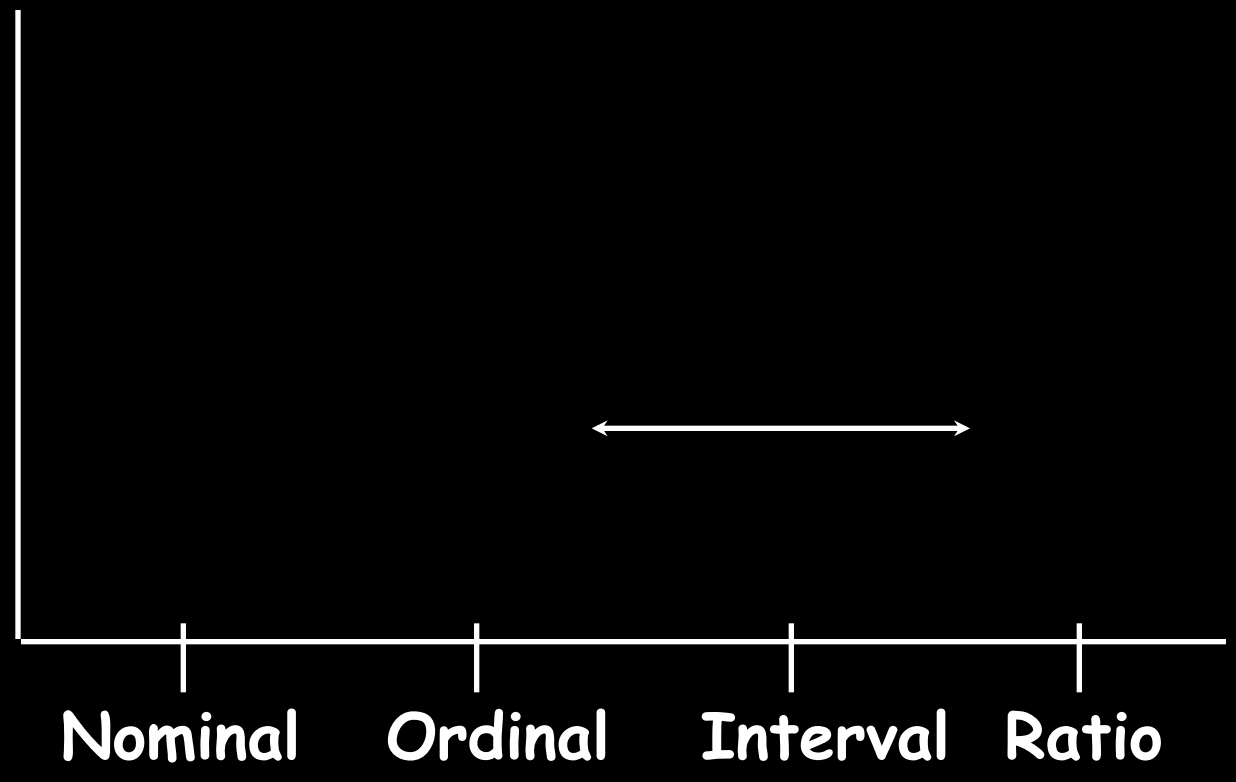
How Are Good Measures Developed?

- Review literature
- Expert input (patients and clinicians)
- Define constructs you are interested in
- Draft items (item generation)
- Pretest
  - Cognitive interviews
  - Field and pilot testing
- Revise and test again
- Translate/harmonize across languages

Scales of Measurement and Their Properties

Type of Scale	Property of Numbers: Rank Order	Equal Interval	Absolute 0
Nominal	No	No	No
Ordinal	Yes	No	No
Interval	Yes	Yes	No
Ratio	Yes	Yes	Yes

Measurement Range for Health Outcome Measures

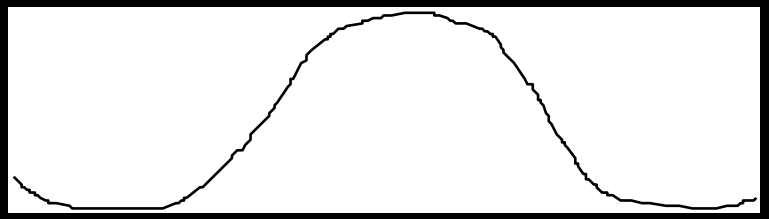


Indicators of Acceptability

- Response rate
- Administration time
- Missing data (item, scale)

Variability

- All scale levels are represented
- Distribution approximates bell-shaped "normal"



Measurement Error

observed = true score + systematic error + random error

(bias)

Flavors of Reliability

- Test-retest (administrations)
- Intra-rater (raters)
- Internal consistency (items)

Test-retest Reliability of MMPI 317-362
r = 0.75

MMPI 362 \ MMPI 317	True	False	
True	169	15	184
False	21	95	116
	190	110	

I am more sensitive than most other people.

Kappa Coefficient of Agreement (Corrects for Chance)

$$\text{kappa} = \frac{(\text{observed} - \text{chance})}{(1 - \text{chance})}$$

Example of Computing KAPPA

		Rater A					
		1	2	3	4	5	Row Sum
Rater B	1	1	1				2
	2		2				2
	3			2			2
	4				2		2
	5					2	2
Column Sum		1	3	2	2	2	10

Example of Computing KAPPA (Continued)

$$P_c = \frac{(1 \times 2) + (3 \times 2) + (2 \times 2) + (2 \times 2) + (2 \times 2)}{(10 \times 10)} = \boxed{0.20}$$

$$P_{obs.} = \frac{9}{10} = \boxed{0.90}$$

$$\text{Kappa} = \frac{0.90 - 0.20}{1 - 0.20} = \boxed{0.87}$$

Guidelines for Interpreting Kappa

Conclusion	Kappa
Poor	< .40
Fair	.40 - .59
Good	.60 - .74
Excellent	> .74

Fleiss (1981)

Conclusion	Kappa
Poor	< 0.0
Slight	.00 - .20
Fair	.21 - .40
Moderate	.41 - .60
Substantial	.61 - .80
Almost perfect	.81 - 1.00

Landis and Koch (1977)

Ratings of Height of Houseplants

Plant		Baseline Height	Follow-up Height	Experimental Condition
A1				
	R1	120	121	1
	R2	118	120	
A2				
	R1	084	085	2
	R2	096	088	
B1				
	R1	107	108	2
	R2	105	104	
B2				
	R1	094	100	1
	R2	097	104	
C1				
	R1	085	088	2
	R2	091	096	

Ratings of Height of Houseplants (Cont.)

Plant		Baseline Height	Follow-up Height	Experimental Condition
C2				
	R1	079	086	1
	R2	078	092	
D1				
	R1	070	076	1
	R2	072	080	
D2				
	R1	054	056	2
	R2	056	060	
E1				
	R1	085	101	1
	R2	097	108	
E2				
	R1	090	084	2
	R2	092	096	

Reliability of Baseline Houseplant Ratings

Ratings of Height of Plants: 10 plants, 2 raters

Baseline Results

Source	DF	SS	MS	F
Plants	9	5658	628.667	35.52
Within	10	177	17.700	
Raters	1	57.8	57.800	
Raters x Plants	9	119.2	13.244	
Total	19	5835		

Sources of Variance in Baseline Houseplant Height

Source	dfs	MS	
Plants (N)	9	628.67	(BMS)
Within	10	17.70	(WMS)
Raters (K)	1	57.80	(JMS)
Raters x Plants	9	13.24	(EMS)
Total	19		

Intraclass Correlation and Reliability

Model	Reliability	Intraclass Correlation
One-Way	$\frac{MS_{BMS} - MS_{WMS}}{MS_{BMS}}$	$\frac{MS_{BMS} - MS_{WMS}}{MS_{BMS} + (K-1)MS_{WMS}}$
Two-Way Fixed	$\frac{MS_{BMS} - MS_{EMS}}{MS_{BMS}}$	$\frac{MS_{BMS} - MS_{EMS}}{MS_{EMS} + (K-1)MS_{EMS}}$
Two-Way Random	$\frac{N(MS_{BMS} - MS_{EMS})}{NMS_{BMS} + MS_{JMS} - MS_{EMS}}$	$\frac{MS_{BMS} - MS_{EMS}}{MS_{BMS} + (K-1)MS_{EMS} + K(MS_{JMS} - MS_{EMS})/N}$

Summary of Reliability of Plant Ratings

	Baseline		Follow-up	
	R_{TT}	R_{II}	R_{TT}	R_{II}
One-Way Anova	0.97	0.95	0.97	0.94
Two-Way Random Effects	0.97	0.95	0.97	0.94
Two-Way Fixed Effects	0.98	0.96	0.98	0.97

Source	Label	Baseline MS
Plants	BMS	628.667
Within	WMS	17.700
Raters	JMS	57.800
Raters X Plants	EMS	13.244

Cronbach's Alpha

Source	df	SS	MS
Respondents (BMS)	4	11.6	2.9
Items (JMS)	1	0.1	0.1
Resp. x Items (EMS)	4	4.4	1.1
Total	9	16.1	

$$\text{Alpha} = \frac{2.9 - 1.1}{2.9} = \frac{1.8}{2.9} = \boxed{0.62}$$

Alpha by Number of Items and Inter-item Correlations

$$\text{alpha}_{st} = \frac{K\,\bar{r}}{1 + (K - 1)\,\bar{r}}$$

K = number of items in scale

Alpha for Different Numbers of Items and Homogeneity

Number of Items (K)	Average Inter-item Correlation ($\bar{r}$)					
	.0	.2	.4	.6	.8	1.0
2	.000	.333	.572	.750	.889	1.000
4	.000	.500	.727	.857	.941	1.000
6	.000	.600	.800	.900	.960	1.000
8	.000	.666	.842	.924	.970	1.000

Spearman-Brown Prophecy Formula

$$\text{alpha}_y = \left(\frac{N \cdot \text{alpha}_x}{1 + (N - 1) * \text{alpha}_x} \right)$$

N = how much longer scale y is than scale x

Number of Items and Reliability for Three Versions of the Mental Health Inventory (MHI)

Example Spearman-Brown Calculations

MHI-18

$$\frac{18/32\ (0.98)}{(1+(18/32\ -1)*0.98}$$

= 0.55125/0.57125 = 0.96

Reliability Minimum Standards

- 0.70 or above (for group comparisons)
- 0.90 or higher (for individual assessment)
  - SEM = SD (1- reliability)$^{1/2}$

Reliability of a Composite Score

$$\text{Mosier} = 1 - \frac{\Sigma(w_j^2)(S_j^2) - \Sigma(w_j^2)(S_j^2)(\alpha_j)}{\Sigma(w_j^2)(S_j^2) + 2\Sigma(w_j)(w_K)(S_j)(S_K)(r_{jK})}$$

w_j = weight given to component J

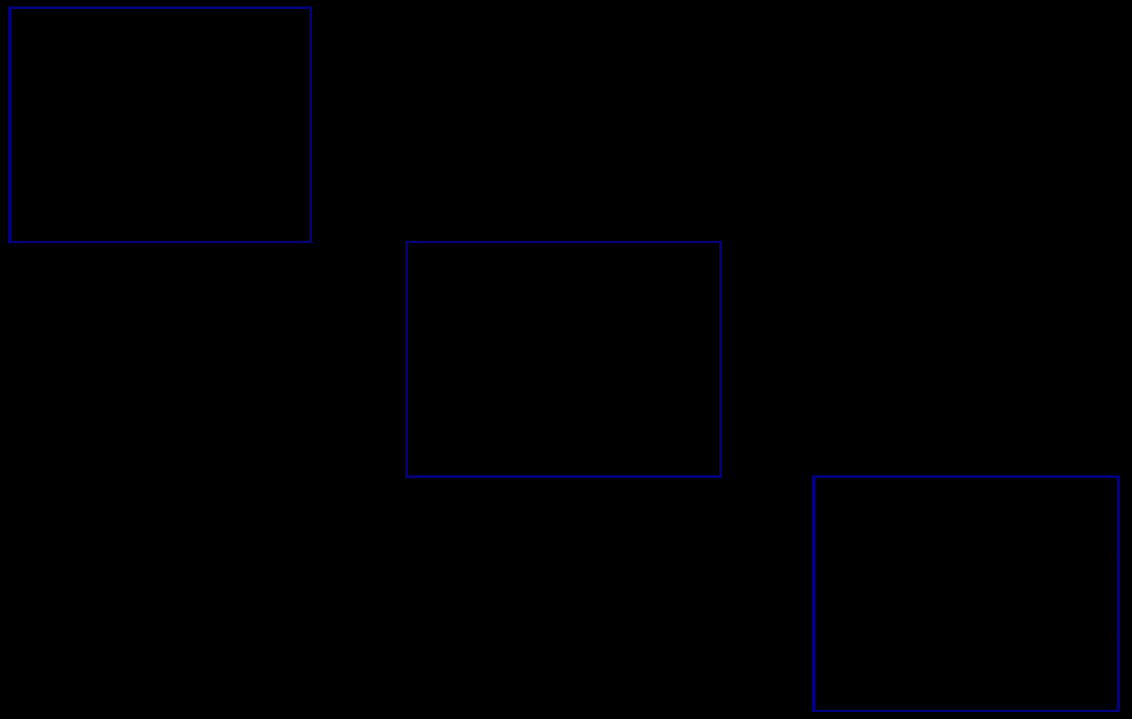
w_K = weight given to component K

S_j = standard deviation of J

α_j = reliability of J

r_{jK} = correlation between J and K

Hypothetical Multitrait/Multi-Item Correlation Matrix



Multitrait/Multi-Item Correlation Matrix for Patient Satisfaction Ratings

	Technical	Interpersonal	Communication	Financial
Technical				
1	0.66*	0.63†	0.67†	0.28
2	0.55*	0.54†	0.50†	0.25
3	0.48*	0.41	0.44†	0.26
4	0.59*	0.53	0.56†	0.26
5	0.55*	0.60†	0.56†	0.16
6	0.59*	0.58†	0.57†	0.23
Interpersonal				
1	0.58	0.68*	0.63†	0.24
2	0.59†	0.58*	0.61†	0.18
3	0.62†	0.65*	0.67†	0.19
4	0.53†	0.57*	0.60†	0.32
5	0.54	0.62*	0.58†	0.18
6	0.48†	0.48*	0.46†	0.24

Note – Standard error of correlation is 0.03. Technical = satisfaction with technical quality. Interpersonal = satisfaction with the interpersonal aspects. Communication = satisfaction with communication. Financial = satisfaction with financial arrangements. *Item-scale correlations for hypothesized scales (corrected for item overlap). †Correlation within two standard errors of the correlation of the item with its hypothesized scale.

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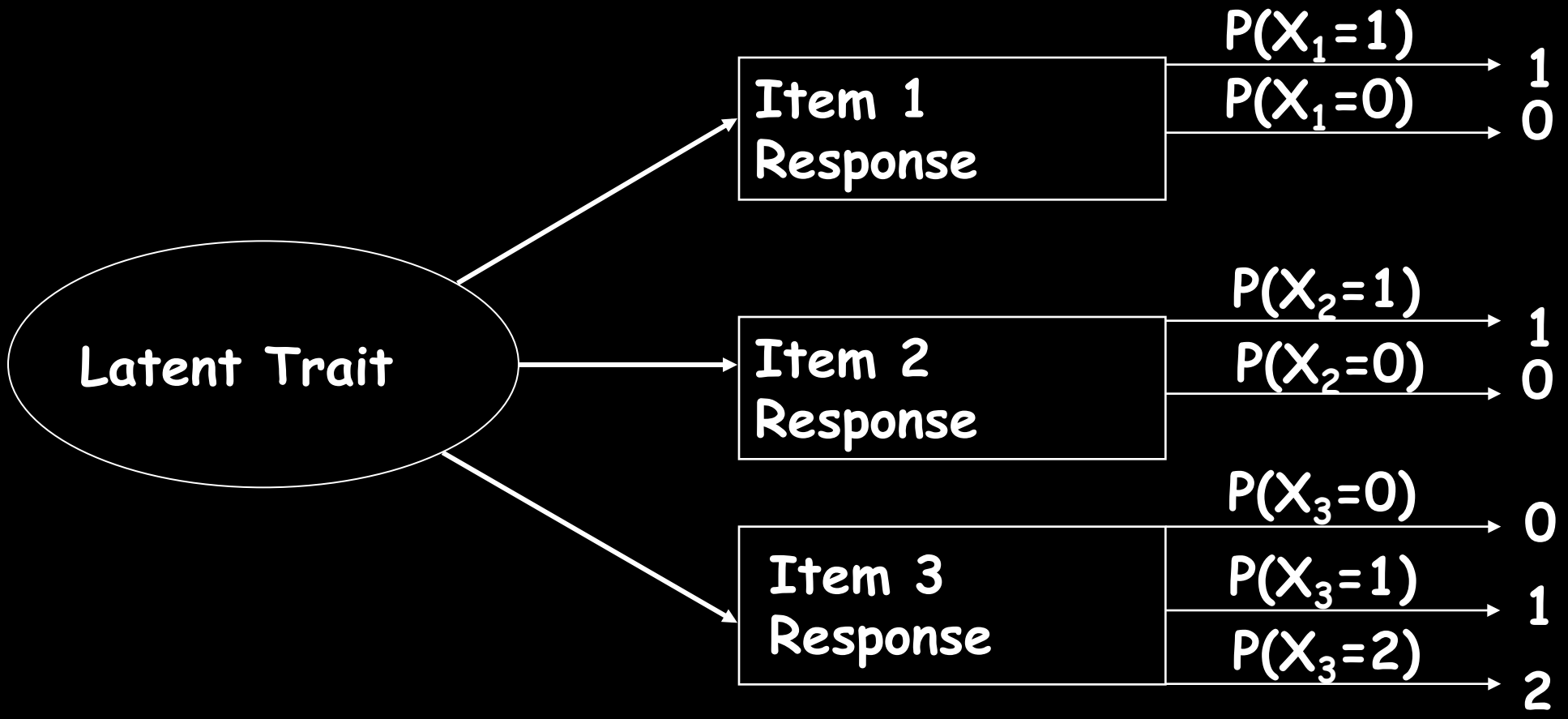
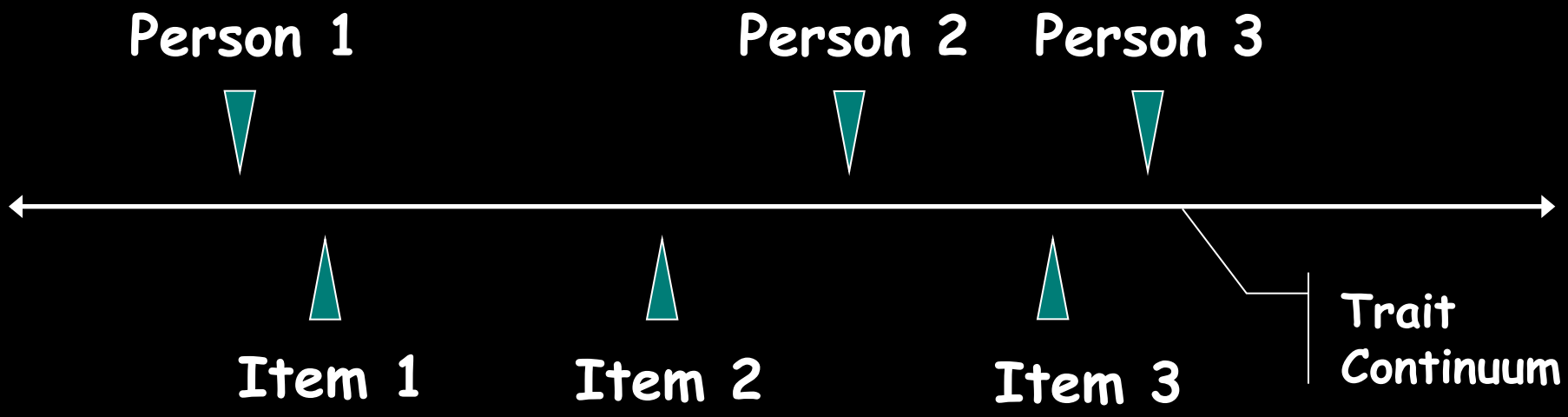
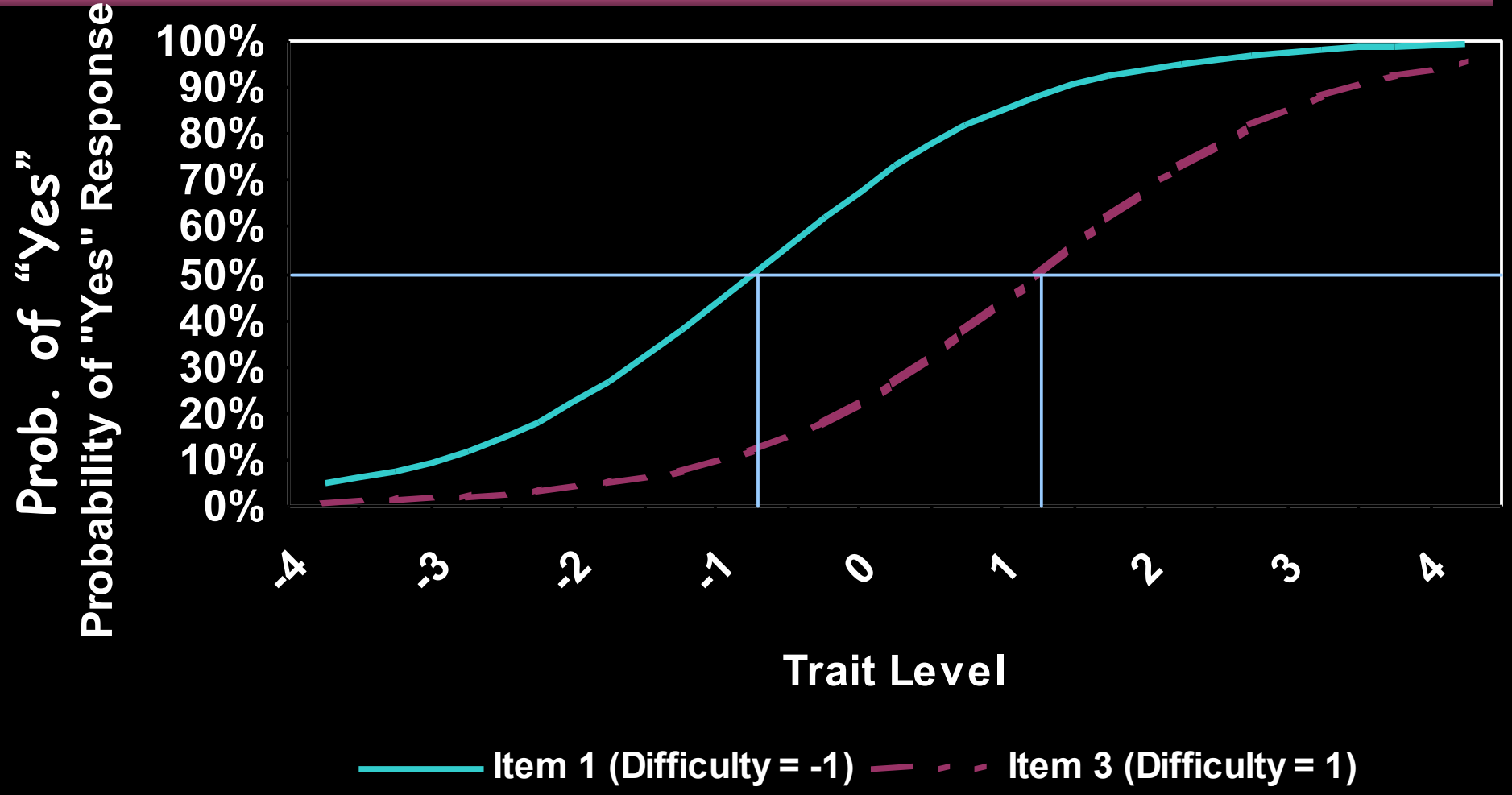
Latent Trait and Item Responses



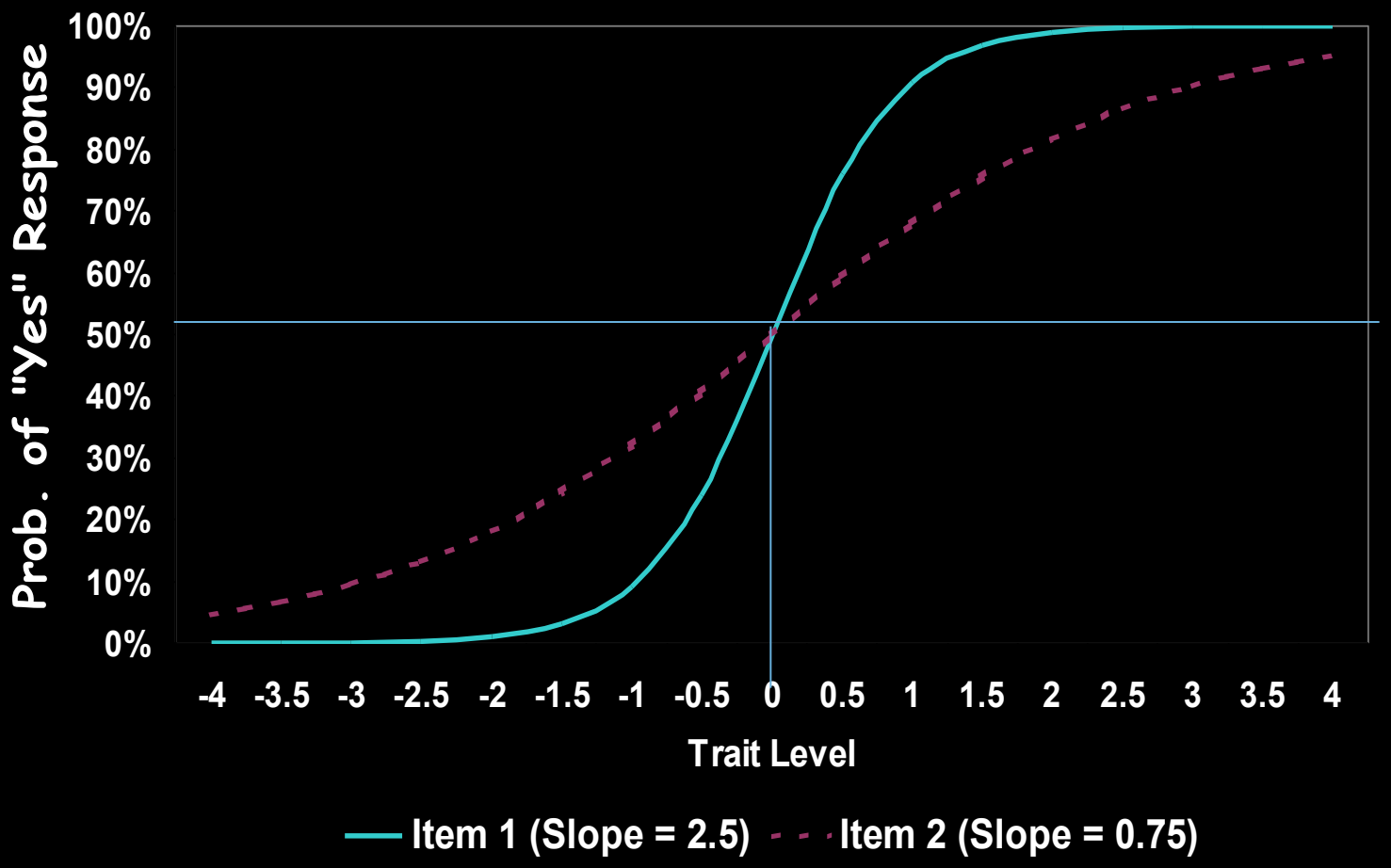
Item Responses and Trait Levels



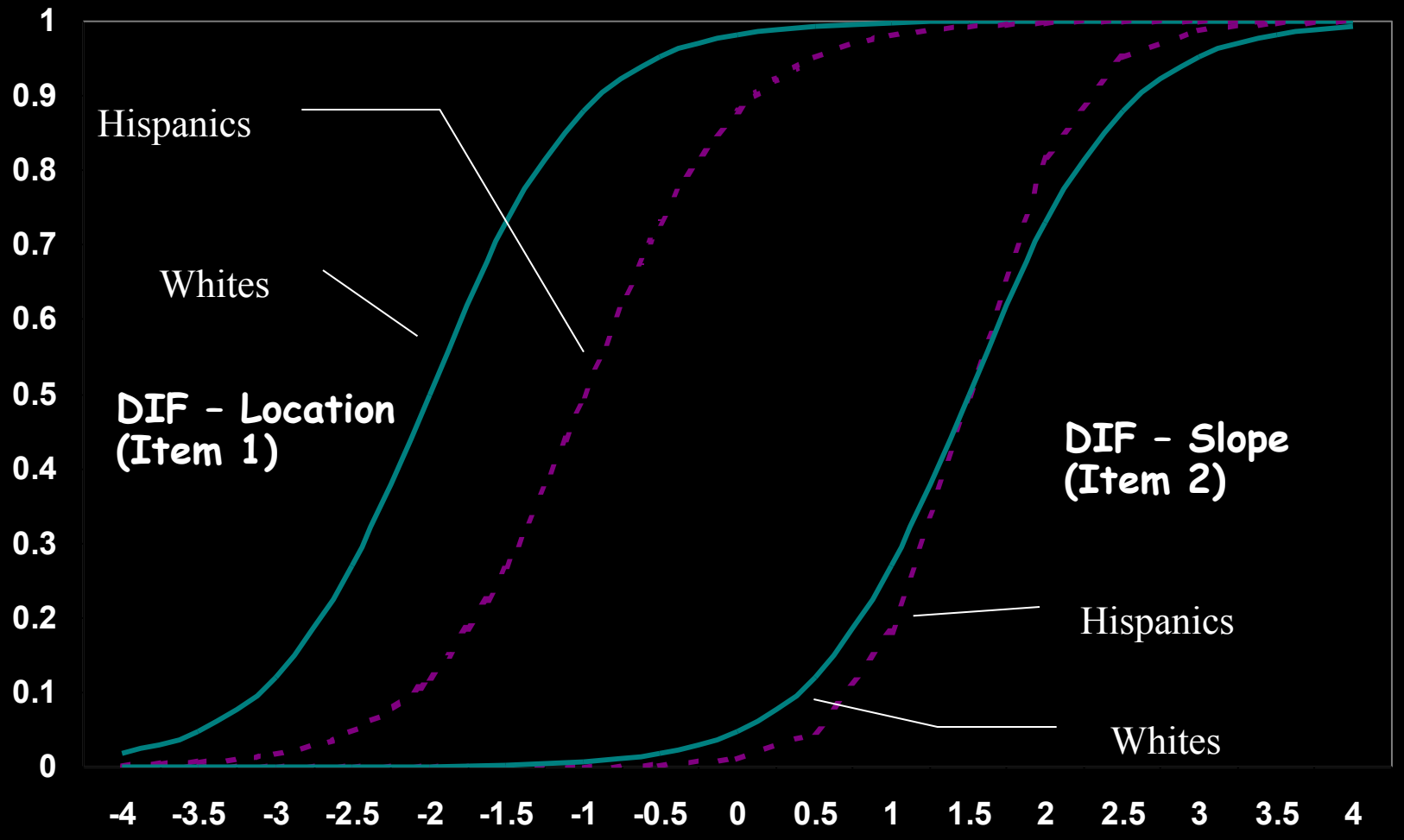
Item Characteristic Curves (1-Parameter Model)



Item Characteristic Curves (2-Parameter Model)



Dichotomous Items Showing DIF
(2-Parameter Model)



Forms of Validity

- Content, Criterion
- Construct Validity

Construct Validity

- Does measure relate to other measures in ways consistent with hypotheses?
- Responsiveness to change

Relative Validity Analyses

- Form of "known groups" validity
- Relative sensitivity of measure to important clinical differences

Relative Validity Example

	Severity of Heart Disease				
	None	Mild	Severe	F-ratio	Relative Validity
Scale #1	91	90	87	2	---
Scale #2	88	78	74	10	5
Scale #3	95	87	77	20	10

Responsiveness to Change and Minimally Important Difference

- HRQOL measures should be responsive to interventions that changes HRQOL

- Evaluating responsiveness requires assessment of HRQOL
  - pre-post intervention of known efficacy
  - at two times in tandem with gold standard

Two Essential Elements

- External indicator of change (Anchors)
  - mean change in HRQOL scores among people who have a "minimal" change in HRQOL.
- Amount of HRQOL change

External Indicator of Change (A)

- **Overall has there been any change in your asthma since the beginning of the study?**

  Much improved; Moderately improved; Minimally improved

  No change

  Much worse; Moderately worse; Minimally worse

External Indicator of Change (B)

Rate your overall condition. This rating should encompass factors such as social activities, performance at work or school, seizures, alertness, and functional capacity; that is, your overall quality of life.

7 response categories; ranging from no impairment to extremely severe impairment

External Indicator of Change (C)

- "changed" group = seizure free (100% reduction in seizure frequency)

- "unchanged" group = <50% change in seizure frequency

Responsiveness Indices

(1) Effect size (ES) = D/SD

(2) Standardized Response Mean (SRM) = D/SD†

(3) Guyatt responsiveness statistic (RS) = D/SD‡

D = raw score change in "changed" group;

SD = baseline SD;

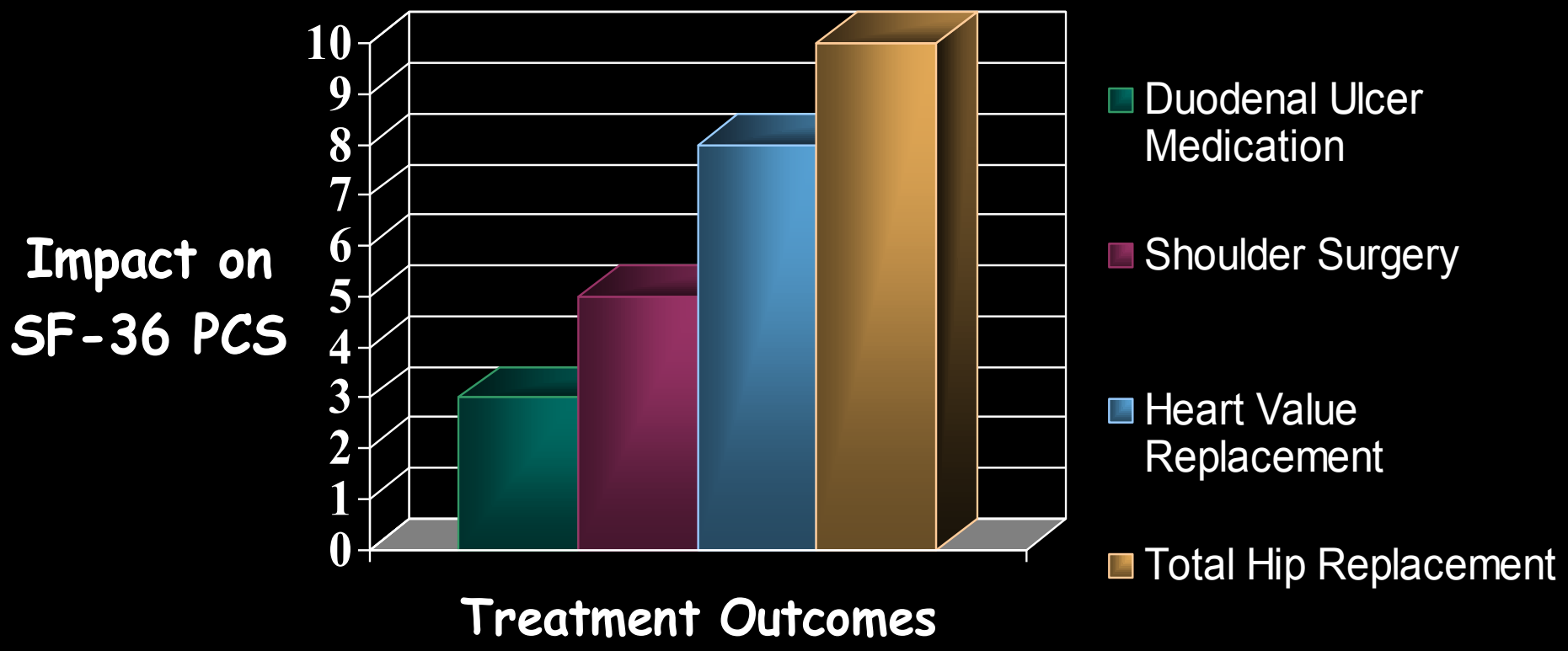
SD† = SD of D;

SD‡ = SD of D among "unchanged"

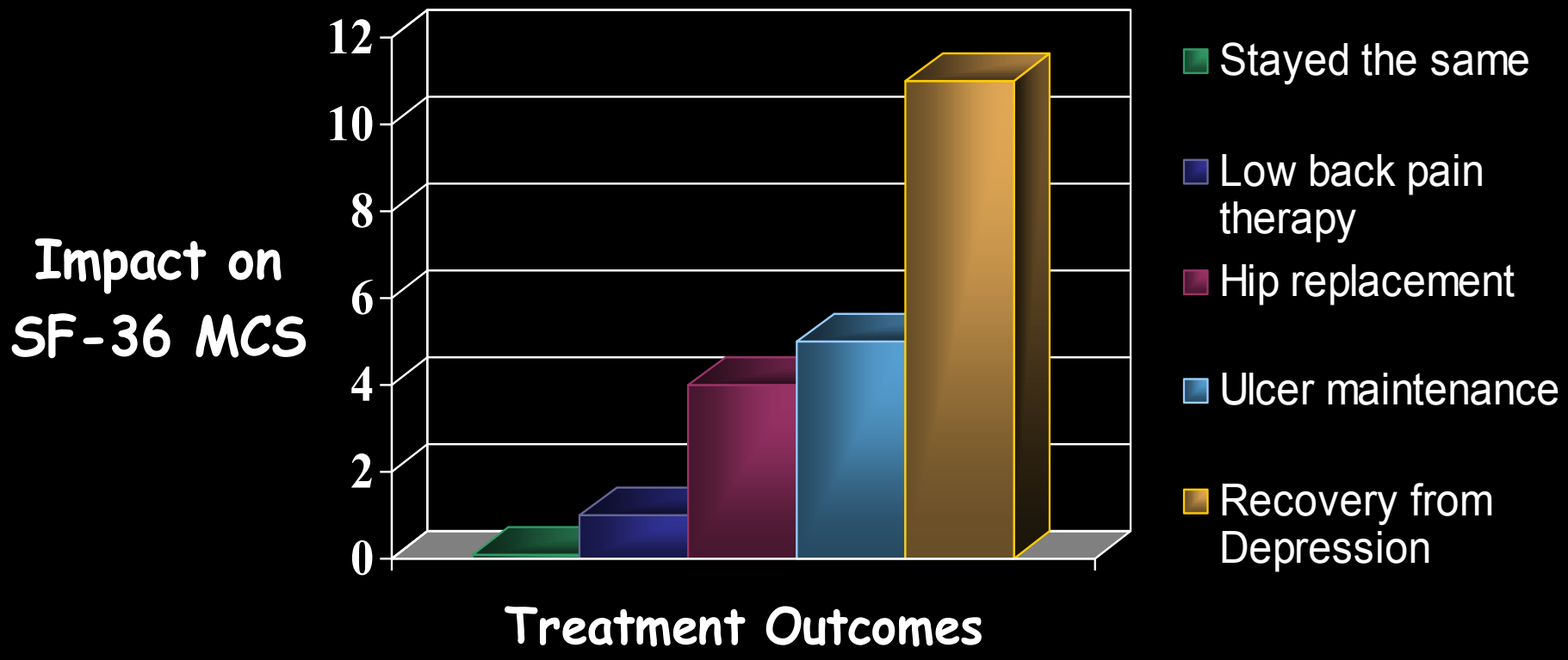
Effect Size Benchmarks

- Small: 0.20->0.49
- Moderate: 0.50->0.79
- Large: 0.80 or above

Treatment Impact on PCS



Treatment Impact on MCS



Individual Change

- Interest in knowing how many patients benefit from group intervention
- Tracking progress on individual patients

Methods

- 54 patients
- Average age = 56; 84% white; 58% female
- Self-administered SF-36 version 2 at baseline and about at end of therapy (about 6 weeks later).

SF-36 Version 2

- Physical functioning (10 items)
- Role limitations/physical (4 items)
- Pain (2 items)
- General health perceptions (5 items)
- Social functioning (2 items)
- Energy/fatigue (4 items)
- Role limitations/emotional (3 items)
- Emotional well-being (5 items)

Scoring the SF-36

- Average or sum all items in the same scale.

- Transform average or sum to
  - 0 (worse) to 100 (best) possible range
  - z-score (mean = 0, SD = 1)
  - T-score (mean = 50, SD = 10)
    - ✓ T-score = 50 + (z-score * 10)

t-test for within group change

- $X_D/(SD_d/n^{1/2})$

X_D = is mean difference, SD_d = standard deviation of difference

Formulas for Significance of Individual Change

Standard error of measurement (SEM)	$SD_b * (1- \text{reliability})^{1/2}$
Standard error of prediction (SEp)	$SD_b * (1- \text{reliability}^2)^{1/2}$
SEM CI around Time 1 score	Time 1 +- 2 SEM
SEp CI around Time 1 score	Time 1 +- 2 SEp

SD_b = standard deviation at baseline

Estimated True Score for Score of 60

- Mean + reliability (score – mean)
- 50 + 0.90 (60 – 50) = 59

Reliable Change Index

- $(X_2 - X_1)$/ (SEM * SQRT [2])

Formulas for Significance of Individual Change

SEM 95% CI	$1.96 * SD_b * (1- \text{reliability})^{1/2}$
SEp 90% CI	$1.64* SD_b * (1- \text{reliability}^2)^{1/2}$
SEp 95% CI	$1.96* SD_b * (1- \text{reliability}^2)^{1/2}$
Estimated true score	Mean + reliability (score – mean)
Reliable change index	$X_2-X_1/$

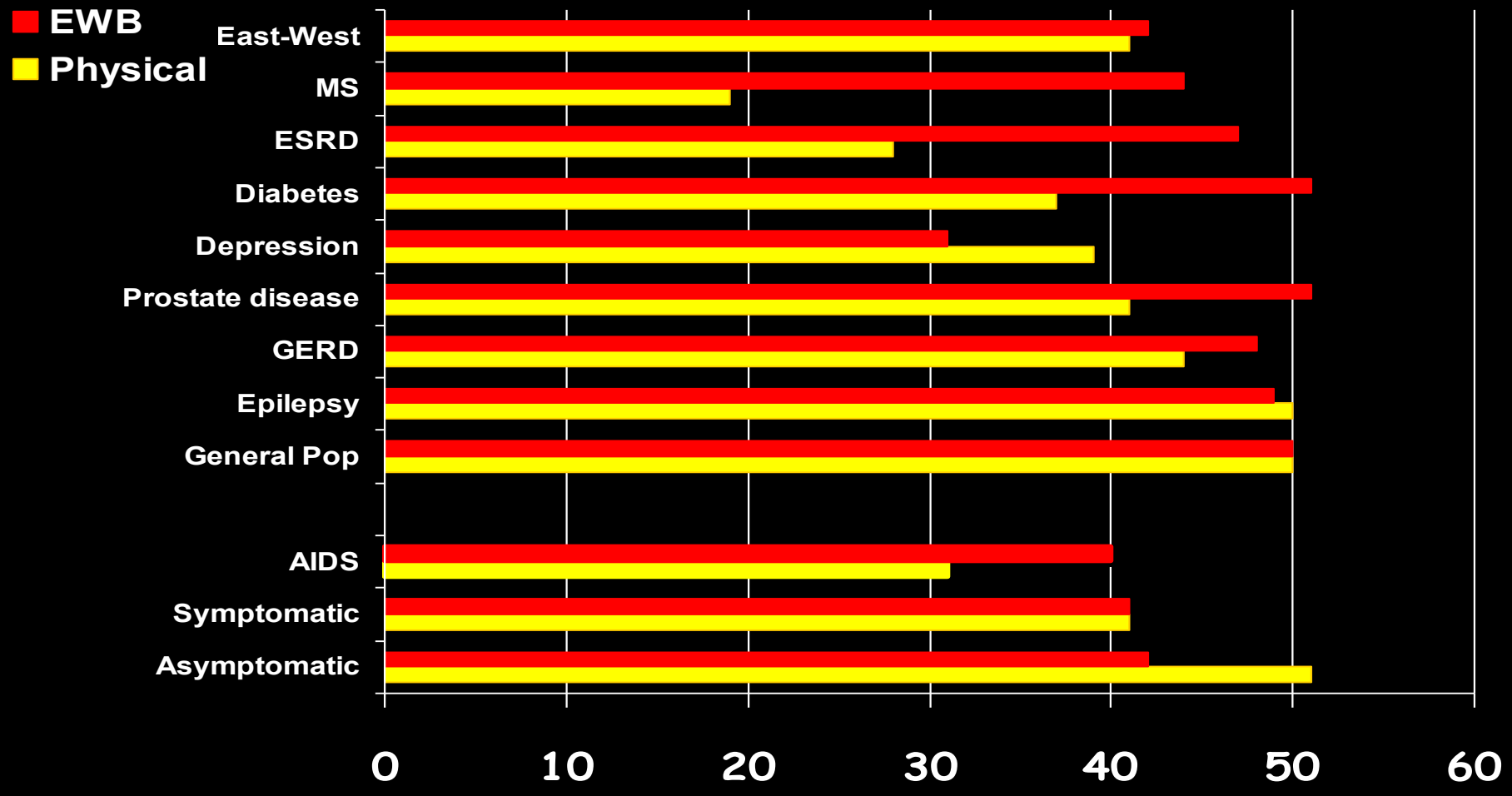
SD_b = standard deviation at baseline

Minimum Delta for Individual Significance

- SEM: > 1.96 SEM
- RCI: > 1.96 * SQRT (2) * SEM

- SEp-90: > 1.64 SEp; SEp-95: > 1.96 SEp

Physical Functioning and Emotional Well-Being at Baseline for 54 Patients at UCLA-Center for East West Medicine



RAND HEALTH

Hays et al. (2000), American Journal of Medicine

Change in SF-36 Scores Over Time

Significance of Group Change

	Delta	t-test	prob.
PF-10	1.7	2.38	.0208
RP-4	4.1	3.81	.0004
BP-2	3.6	2.59	.0125
GH-5	2.4	2.86	.0061
EN-4	5.1	4.33	.0001
SF-2	4.7	3.51	.0009
RE-3	1.5	0.96	.3400 <-
EWB-5	4.3	3.20	.0023
PCS	2.8	3.23	.0021
MCS	3.9	2.82	.0067

Amount of Change in Observed Score Needed for Significant Change

	SEM	90% SEp	95% SEp	RCI	Effect size
PF-10	5.9	6.9	8.2	8.4	0.47-0.67
RP-4	6.0	6.9	8.3	8.4	0.52-0.72
BP-2	7.4	8.4	10.1	10.4	0.72-1.01
GH-5	9.2	10.4	12.5	13.0	0.80-1.13
EN-4	9.0	10.1	12.0	12.8	0.94-1.33
SF-2	9.8	11.1	13.3	13.8	0.76-1.07
RE-3	6.8	8.0	9.5	9.7	0.50-0.71
EWB-5	9.5	10.6	12.7	13.4	0.90-1.26
PCS	5.0	5.9	7.0	7.1	0.43-0.62
MCS	6.9	8.0	9.5	9.7	0.52-0.73

Proportion of 54 Cases Declining Significantly

	SEM	SEp 90	SEp 95	RCI
PF-10	9%	7%	2%	2%
RP-4	7%	6%	2%	2%
BP-2	17%	11%	9%	7%
GH-5	4%	0%	0%	0%
EN-4	4%	4%	2%	2%
SF-2	13%	11%	6%	4%
RE-3	19%	19%	15%	15%
EWB-5	9%	6%	6%	4%
PCS	7%	7%	7%	7%
MCS	13%	11%	11%	11%

Proportion of 54 Cases Improving Significantly

	SEM	SEp 90	SEp 95	RCI
PF-10	19%	15%	13%	13%
RP-4	35%	31%	30%	31%
BP-2	31%	28%	24%	22%
GH-5	9%	7%	7%	7%
EN-4	24%	17%	11%	9%
SF-2	30%	20%	17%	17%
RE-3	24%	19%	15%	15%
EWB-5	26%	20%	19%	19%
PCS	33%	30%	24%	24%
MCS	37%	30%	22%	22%

% Improved - % Declined

	SEM	SEp 90	SEp 95	RCI
PF-10	10%	8%	11%	11%
RP-4	28%	25%	28%	29%
BP-2	14%	17%	15%	15%
GH-5	5%	7%	7%	7%
EN-4	11%	13%	9%	7%
SF-2	11%	9%	11%	13%
RE-3	5%	0%	0%	0%
EWB-5	19%	14%	13%	15%
PCS	26%	23%	17%	17%
MCS	24%	19%	11%	11%